F₁ ATP Synthase

Andrea Pasqua
Oct 26 2006
Why $F_1$?

- It is probably the best understood molecular motor. Therefore a paradigm.
Why $F_1$?

- It is probably the best understood molecular motor. Therefore a paradigm.
- It has a truly fundamental biological role.
Why $F_1$?

- It is probably the best understood molecular motor. Therefore a paradigm.
- It has a truly fundamental biological role.
- I work for the Expert after all.
Outline

I. What does it do and where it is to be found.
II. What does it look like.
III. Physical models.
I. $F_1$ Function

- ATP Hydrolysis/Synthesis.

\[
ATP + H_2O \rightarrow ADP + P_i.
\]
I. F₁ Function

- ATP Hydrolysis/Synthesis.
- A torque is required to perform synthesis ($F_0$).
I.  F₁ Function

- ATP Hydrolysis/Synthesis.
- A torque is required to perform synthesis (F₀).
- Conversely a torque is exerted during hydrolysis.
I. F$_1$ Function

- ATP Hydrolysis/Synthesis.
- A torque is required to perform synthesis (F$_0$).
- Conversely a torque is exerted during hydrolysis.
- The torque originates from p$^+$ gradient (sometimes Na$^+$)
I. $F_1$ in Nature

- $F_1F_0$ complexes are found in bacteria, mitochondria and chloroplasts.
I. **F$_1$ in Nature**

- F$_1$F$_0$ complexes are found in bacteria, mitochondria and chloroplasts.
- Same functional parts.
I. F₁ in Nature

- F₁F₀ complexes are found in bacteria, mitochondria and chloroplasts.
- Same functional parts.
- Where is it located?
I. $F_1$ in Nature

- $F_1F_0$ complexes are found in bacteria, mitochondria and chloroplasts.
- Same functional parts.
II. \( F_0F_1 \) structure
II. $F_0F_1$ structure
II. $F_0F_1$ structure

- An alternative (functional) subdivision: rotor and stator.
II. Evidence for a Rotor

- Actin Filament.

W. Junge, H. Lill & S. Engelbrecht
TIBS 22, 420 - 423 (1997)
II. Evidence for a Rotor

- Actin Filament.
- Chromophore.
II. Evidence for a Rotor

- Actin Filament.
- Chromophore.
II. Evidence for a Rotor

- Actin Filament.
- Chromophore.
- Biochemistry.
II. Evidence for a Rotor

Duncan et al.
II. Beta and Gamma units
II. Beta and Gamma units
II.  Yet two more pictures
Parenthesis on $F_0$

- Proton translocation (sometimes $\text{Na}^+$)
Parenthesis on $F_0$

- Proton translocation (sometimes $\text{Na}^+$)

\[ \Delta \mu_{\text{H}^+} = -e\Delta \Phi + \ln(10)kT \left( p\text{H}_{\text{out}} - p\text{H}_{\text{in}} \right) \]
Parenthesis on $F_0$

- Proton translocation (sometimes $\text{Na}^+$)
- How is torque generated?
Parenthesis on $F_0$
Parenthesis on $F_0$
III. Physical Models

- What is the general idea?
III. Physical Models

- A simplified model: Eide et al.
III. Physical Models

- A simplified model: Eide et al.
III. Eide et al.
III. Eide et al.
III. Eide et al.

- Analysis:
  - Langevine Equation
  - Implicit treatment of solvent.
  - More complex 3D model with realistic geometry and explicit solvent.
III. Eide et al.

- Findings:
  - Force curve is smooth, except when many bonds are formed.
  - Repetition of the cycle requires cooperativity.
III. Eide et al.

A. 

- Velocity vs. Load Force (pN)
  - 22 sites
  - 16 sites
  - 6 sites
  - 11 sites

B. 

- Velocity vs. Number of Surface Sites
- Graph showing velocity changes with increasing number of surface sites.

C. 

- Power vs. Load Force [pN]
  - 22 Sites
  - 16 Sites
  - 6 Sites
  - 11 Sites

D. 

- Heat vs. Load Force [pN]
  - 22 sites
  - 6 sites
  - 11 sites
Acknowledgements

- George and the group.